National Bureau of Standards

TECHNICAL NEWS BULLETIN

NOVEMBER 1946 No. 355

Meteors Detected by Radar

Scientists of the Bureau are now using radar to investigate the ionization caused by meteors. Beginning the night of October 7 and continuing through October 12, reflections from the meteor shower associated with the Giacobini-Zinner Comet were clearly visible on the oscilloscope screens of the radar set at Sterling, Va. The investigations, which are to be continued, are expected to indicate the effect of meteors on radio waves, particularly important in FM broadcasting and long-range radio communication and navigation. Moreover, the technic is significant in astronomy as a method of observation on overcast nights and during the day, when meteors are not visible.

Signals were observed on both the A and PPI oscilloscopes of the radar set. A photographic record was kept of the PPI indications, while the A scope was monitored by an operator who kept a log of the time, range, and approximate duration of the reflections. The peak of the meteor shower was expected on the evening of October 9. The rate of occurrence rose from approximately eight per hour between 7:30 p. m. and 8:30 p. m. to a peak of over one per minute between 10:30 p. m. and 11:00 p. m., coinciding approximately with the predicted time of 10:00 for the maximum intensity of the Draconid shower. Following this maximum, the rate fell to about 20 per hour after 11:15 p. m. Distances ranged from about 60 to 200 miles. Duration of the transient radar reflections was usually 1 second or less, although a considerable number lasted for several seconds. Only a few appeared to change distance during the time that they could be observed on the screen, and the change was of the order of 5 miles or less.

The radar used in these investigations is the standard Signal Corps type SCR–270–D, operating at about 107 megacycles and transmitting 25 microsecond pulses at a repetition rate of 400 per second, with a peak power of approximately 100 kilowatts. The antenna was oriented at an azimuth of 315 degrees and an elevation of 45 degrees. The width of the main beam of the radar antenna, consisting of 32 dipoles arranged in a rectangular array, was approximately 40 by 20 degrees between half-power points, the major axis being vertical.

Although meteors weighing several tons occasionally strike the earth, the solid matter in most visible meteors weighs only a few thousandths of a gram. The frictional heat generated by their high rate of travel through the atmosphere is sufficient to vaporize the solid matter, and produce a trail of hot ionized gas in the neighborhood of the meteor. It is this trail of hot gases that produces the visible glow. These gases and the adjacent atmosphere at the time of passage of the meteor are apparently highly ionized.

Ionospheric investigations have shown that ionized gases will reflect radio waves below a given frequency, allowing higher frequency waves to pass through. The frequency that will just be reflected by a region of ionized gases is proportional to the square of the density of ions. Because of the amount of frictional energy dissipated by a meteor, the hot gases in its trail should be ionized for a brief instant to a much greater extent than is the ionosphere. It is known that the 100-megacycle radar waves are able to penetrate the ionosphere. However, the ionization in the trails of meteors should be sufficiently intense to reflect radio waves at least in the region of 100 megacycles—a frequency relatively low in terms of modern radar, but much higher than the frequencies used for long-distance sky-wave radio communication.

Supporting evidence for these contentions was the fact that interference encountered on the old frequency modulation broadcasting frequencies in the form of "bursts" (parts of programs from long-distance stations interfering with local station performance) had been found to coincide with the appearance of meteors. Further, it had been reported that during the war radar operators tracking V2 rockets had been confused by reflections from meteors. Other radar observers, such as O. P. Ferrell, working in an unofficial capacity in India, had actually made observations which coincided with the visual observations of meteors.

Simultaneously with the work of the National Bureau of Standards, observations were conducted independently by the Signal Corps in New Jersey, using radars on 600 and 1,000 megacycles, but with no results. These negative findings were as valuable as the positive findings elsewhere, because they indicated that the ionization density reached in these meteors is such that the upper limiting frequency which they could reflect is between 100 and 600 megacycles.

One way in which meteors may affect radio waves is to cause the "bursts" on FM channels. Some scientists, such as J. A. Pierce of Cruft Laboratory, Harvard Uni-

versity, believe that a large part of the ionization of the E layer of the ionosphere may be caused by meteors. A knowledge of the behavior of the E layer is of primary importance since it controls radio propagation on many of the frequencies used for radio communication and radio navigation. Out of the research on the effect of such phenomena will come decisions as to which frequencies are the best for the various types of radio services. These recent tests, together with the observations made on the moon, indicate that radar, besides being a plane locator and navigation device, is a valuable tool for the study of radio-wave propagation and, again, is finding a place as an observing instrument in the field of astronomy.

TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE
W. AVERELL HARRIMAN, *Secretary*
NATIONAL BUREAU OF STANDARDS
E. U. Condon, *Director*

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Contents

Plastic Bonds Resistant to Temperature Changes

Satisfactory bonding between a plastic and a metal facing or metal reinforcement has been practically impossible in the past, primarily because the two types of materials differ in their coefficients of expansion. Plastics have relatively high coefficients of expansion, in contrast to metals, and changes in temperature create forces that prevent satisfactory bonds. Investigations by P. S. Turner of the Plastics Section have shown that the coefficients of thermal expansion of components can be matched, using a formula that relates the density, modulus of elasticity, and proportion by weight of the ingredients to the thermal expansion coefficients.

Bonds produced by adhesives fall into two classes: the rubbery or yielding bond and the rigid bond. The first category includes most thermoplastic cements, rubber cements, and combinations of thin rubber layers and cements. These adhesives provide durable bonds between dissimilar materials at moderate temperatures. The rigid bond has generally proved unsatisfactory for such applications with the possible exception of cold-setting cements of phenol-formaldehyde and urea-formaldehyde types. At reduced temperatures, however, the yielding adhesives lose their ability to eliminate stress concentrations by yielding with the dimensional changes of the materials bonded. If it can be obtained, the rigid bond is superior for many purposes because it produces a stronger and less-yielding product. For composite structural material subjected to extreme temperature changes, a stable rigid bond is imperative. The solution lies in the matching of thermal-expansion coefficients of the components.

The formula developed by P. S. Turner indicates the resulting volume thermal coefficient of a mixture

$$\beta_r=\frac{\dfrac{\beta_1P_1K_1}{d_1}+\dfrac{\beta_2P_2K_2}{d_2}+\cdots+\dfrac{\beta_nP_nK_n}{d_n}}{\dfrac{P_1K_1}{d_1}+\dfrac{P_2K_2}{d_2}+\cdots+\dfrac{P_nK_n}{d_n}},$$

where β is the coefficient of cubical thermal expansion, K is the bulk modulus, P is the fraction or percentage by weight, d is the density, and the numerical subscripts refer to the particular constituents while r refers to the resultant mixture. As the coefficient of linear expansion is directly proportional to the cubical coefficient, a substitution of the former in the above equation is possible. Moreover, for a mixture whose components have nearly equal values of Poisson's ratio, Young's moduli may be used in place of the bulk moduli.

The formula has been used successfully in a number of applications. A mixture of polystyrene and aluminum oxide, for example, was determined in this fashion so that brass inserts were feasible. Brass inserts in ordinary polystyrene cause the polystyrene to crack as a result of the differences in thermal-expansion coefficients. The coefficient of linear expansion of polystyrene is approximately 70×10^{-6} per degree centigrade, whereas that of brass is about 17×10^{-6}. Fused aluminum oxide was chosen for use in the mixture because it has a low coefficient of linear thermal expansion, 8.7×10^{-6}, and a high modulus of elasticity compared to its density. Its choice for use with polystyrene was also determined by its desirable electrical properties, and there was no appreciable change in the electrical resistance of polystyrene on addition of the filler.

Calculations revealed that approximately 90 percent of polystyrene and 10 percent of aluminum oxide would be required to match the coefficient of linear thermal expansion of brass. Analysis with polarized light indi-

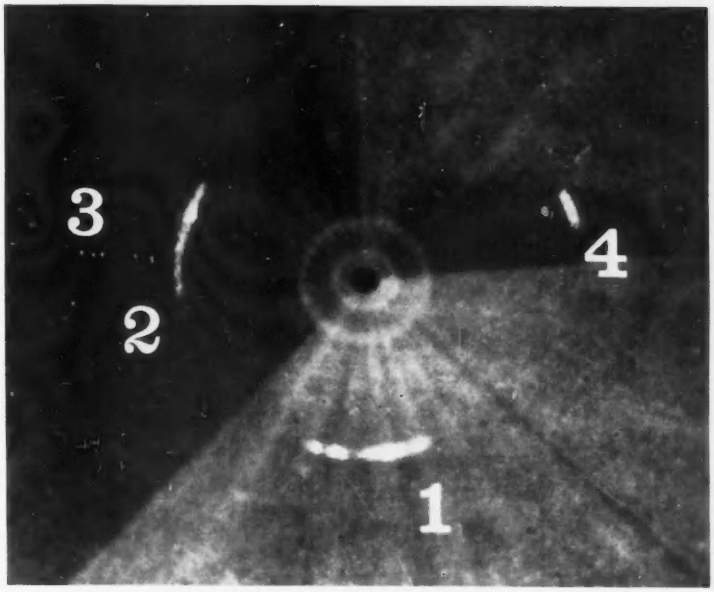


FIGURE 1.—*Four meteor echoes appearing on the PPI radar screen on the night of October 9, 1946, during observations by scientists of the National Bureau of Standards.*

Trace (1) indicates an approximate range of 75 miles and an echo duration of 15 seconds; (2) range 75 miles, duration 13 seconds; (3) range 100 miles, duration ⅓ second; (4) range 85 miles, duration 3⅔ seconds.

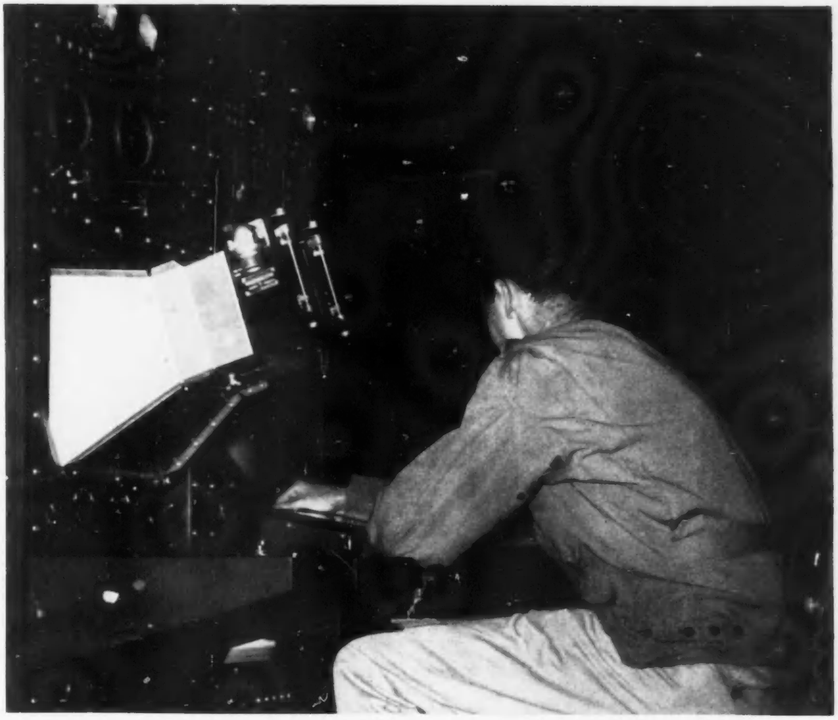


FIGURE 2.—*Receiver console of the SCR-270-D radar set used by the National Bureau of Standards to detect meteors.*

At the right is the *A* scope; components of the camera unit used to photograph the meteor reflections cover the *PPI* scope at the left.

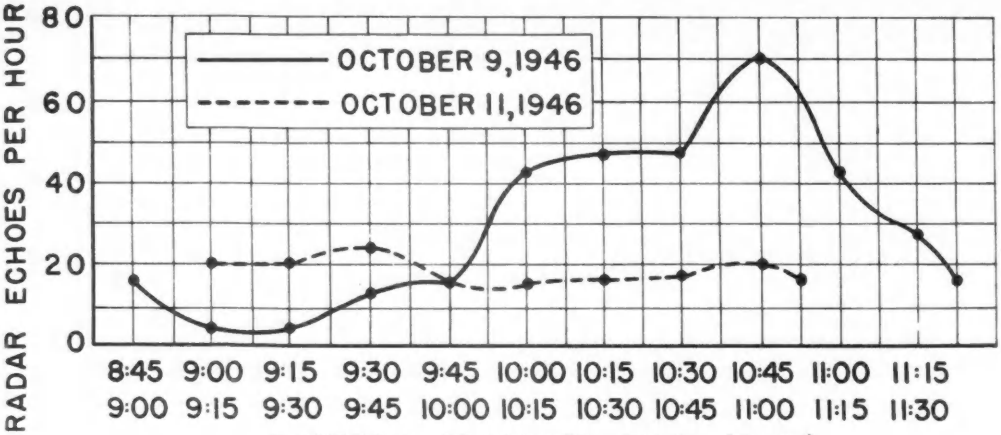


FIGURE 3.—*Rate of occurrence of echoes on the nights of October 9 and 11, 1946.*

Astronomers had predicted the maximum hourly rate of occurrence of the Draconids for the night of October 9.

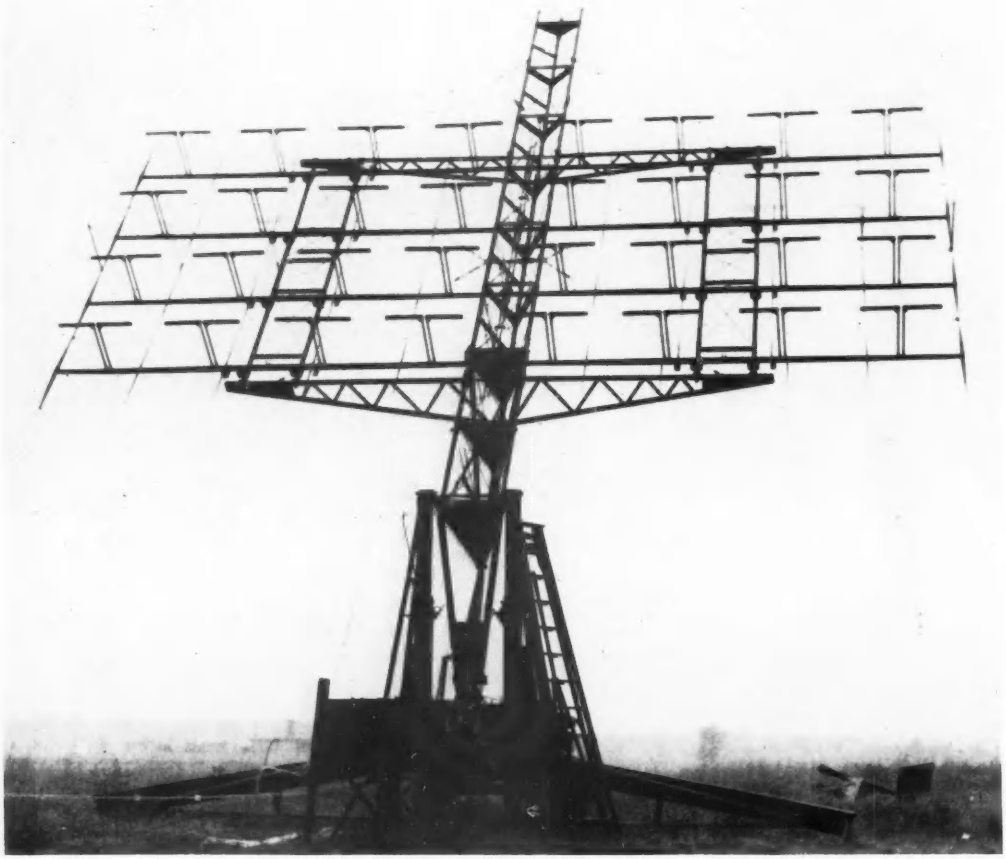


FIGURE 4.—*Antenna of the SCR–270–D radar set.*

The antenna, consisting of 32 dipoles arranged in a rectangular array, was oriented at an azimuth of 315 degrees and an elevation of 45 degrees during the observations of the meteor shower associated with the Giacobini-Zinner Comet.
The width of the main beam is approximately 40 by 20 degrees between half-power points, the major axis being vertical.

cates that there are stresses in the pure polystyrene concentrated at the boundaries between the brass and polystyrene, and these are sufficient to rupture the polystyrene. With about 10 percent of fused aluminum oxide filler, such stress concentrations are absent, and there is no evidence that the filled styrene has fractured. The brass was sufficiently well bonded to the polystyrene to permit sawing and machining of the composite material.

Rivet fillers for aluminum, used to cover the depressions caused by riveting, have also been developed by this method as well as a mixture of glass fiber and phenolic resin designed to match aluminum alloy metal reinforcing plates. The technique permits the formulation of pigmented protective coatings that have satisfactory adhesion to the coated material. In general, the method provides information leading to the proper combination of materials for a matching of thermal coefficients, which in turn yields stable bonds even between large sections and over extreme temperature changes.

Liquid Oxygen Boost of Aircraft Engine Power at Altitude

The desirability of increasing the power of aircraft engines at altitude for emergency use in combat during the war led to extensive research by the Bureau's Aircraft Engines Section under the direction of Ernest F. Fiock. Comprehensive series of ground and flight tests demonstrated the practicability of boosting engine power at altitude by injecting liquid oxygen into the carburetted mixture of motor fuel and air. This increased the speed as much as 40 miles per hour above the maximum obtainable with the best grades of aviation gasoline.

In the rarefied atmosphere 5 to 7 miles above the earth, tremendous increases of power are needed for further acceleration of aircraft at high speeds. Investigations of the effects on engine performance of certain organic nitro compounds, oxides of nitrogen, hydrogen peroxide solutions, and pure gaseous and liquid oxygen indicated that liquid oxygen was the most promising for immediate service application. Efforts were therefore concentrated on liquid oxygen.

In flight tests at 28,000 feet, it was found that there was a boost of about 400 horsepower with a 39-mile per hour increase of speed after liquid oxygen injection was started. The total amount of fuel consumed per horsepower-hour decreased slightly. An increase of 200 horsepower and 15 miles per hour was shown at 35,000 feet.

The injection of liquid oxygen did not increase the tendency of the charge in the engine cylinder to detonate. However, as the injected oxygen is not accompanied by the usual four volumes of nitrogen, cylinder-head temperatures are higher than during operation with air containing the same total quantity of oxygen. Since these head temperatures approach the limiting permissible values during take-off, the injection of liquid oxygen is to be avoided at all altitudes at which the engine can develop its normal rated power when operated on air alone.

From the standpoint of head temperatures and backfiring, results indicate that the total concentration of oxygen in the inducted charge should not exceed 29 percent by weight. At lower concentrations, it is safe to increase the power of the engine at altitude by the injection of liquid oxygen, thereby achieving worthwhile increases in speed, rate of climb, and ceiling of the airplane.

The advantages of such a method of increasing power are that it can be applied readily to existing aircraft and that the complete injection system can be light in weight. The total weight of the charged oxygen system is about 200 pounds, of which 100 pounds is liquid oxygen, sufficient for 16 minutes of operation at a boost of 300 brake horsepower.

On the other hand, the lack of manufacturing facilities and the necessity of transporting and storing liquid oxygen in well insulated containers are the principal disadvantages. Liquid oxygen itself is not an explosive and is hazardous only because it will increase the rate of combustion in any existing fire. With the oxygen apparatus developed at the Bureau, however, the method seemed entirely safe: 19 tons of liquid oxygen were used without accident during the course of tests.

Although the tests were of an experimental nature and no service installation was made, the development of the method was carried to the stage where it could have been applied directly, had the need arisen.

Division of Mineral Products

Effective September 24, 1946, Division IX, formerly known as the Division of Clay and Silicate Products, was designated the Division of Mineral Products. The work of this Division, as heretofore, is confined to nonmetallic mineral products.

At the same time a new section on Constitution and Microstructure was established, with Dr. Herbert Insley as chief. This section comprises two laboratories: (1) The Laboratory of Microscopic and Diffraction Analysis, the purpose of which is the development of technic and methods of analysis of mineral products by X-ray and electron diffraction; H. F. McMurdie is in charge of this laboratory; and (2) the Crystal Synthesis Laboratory, which will study constitution, synthesis, and phase relations at high temperatures, under Dr. Insley.

Certain changes in the names of the sections were also made, so that Division IX now consists of the following sections: 1. Porcelain and Pottery; 2. Glass; 3. Refractories; 4. Enameled Metals; 5. Constitution and Microstructure; 6. Concreting Materials; 7. Masonry and Reinforced Concrete; 8. Lime and Gypsum; 9. Building Stone.

Optical Glass—Research and Production at the Bureau

Optical glass, indispensible in precision optical instruments for military as well as scientific and industrial use, has been developed and produced by the Bureau in large quantities ever since World War I. Ordinarily the Bureau's work ends with research and development, but the lack of available manufacturing facilities and scientific knowledge in this field have combined to expand the experimental glass plant of the Bureau into a manufacturing unit in both wars. As much as a quarter million pounds of extremely high quality optical glass were thus produced in a single year of World War II. At the same time, research and experimental production continued. Improved methods of operation and improved equipment have resulted from these researches, and a number of new types of optical glass have been developed for particular purposes.

Special grades of glass are required for the optical elements of such precision instruments as telescopes, microscopes, periscopes, and range finders. Specifications for optical glass are very rigid, for the slightest imperfection may render an entire instrument useless. In addition to possessing an index of refraction within a very close tolerance, the glass must be homogeneous and free from flaws, chemically and physically stable, highly transparent, and without color.

Specialized Technics for Optical Glass

The ultimate aim of the optical glass maker is to produce a glass that is as nearly free of defects as possible. Two of the most common defects are "seeds" and "striae." Seeds are small bubbles of air trapped in the molten glass, and remaining after it cools. Striae are fine threads of glass of a composition slightly different from the main body of the glass and therefore of a different refractive index. Both defects are present to some extent in practically all optical glass, and when excessive interfere with the performance of the optical elements of instruments. Beginning with raw materials of the highest purity and continuing until the glass leaves the plant, careful planning and extreme care in each step of the manufacturing operation are required.

Pure glass requires pots that will resist attack from the molten glass and that will not introduce impurities through interaction with the glass. The highest quality optical glass is made in pots that are used only once. Pots meeting the requirements peculiar to the manufacture of optical glass have been developed by the Bureau's Refractories Laboratory.

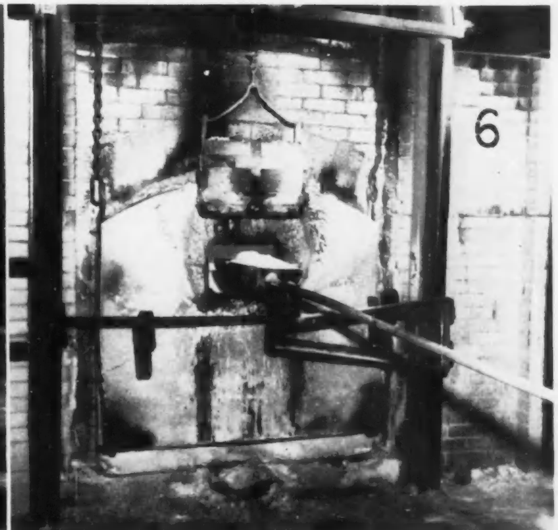
The pots are made up of four chief constituents: feldspar, bonding clay, kaolin, and material from previously used pots. For the more corrosive glasses, a dense low-porosity lining is added. Cast in plaster of paris molds by the process known as slip casting, they are removed from the molds as soon as they have dried sufficiently to handle, air-dried for several weeks, and then fired up to the melting temperature of the glass they are designed to hold. At the time that the pots are made, stirring thimbles are also prepared from the same material and submitted to the same treatment as the pots.

A well-defined procedure and fairly close schedule are followed in the melting of a pot of glass. The pot is first placed in the melting furnace and brought up to the melting temperature of the glass that it is to hold. The charge of batch and cullet (waste glass from previous melts) is then introduced. A typical batch for a borosilicate crown glass, for example, would include sand, boric acid, borax, soda ash, saltpeter, zinc oxide, arsenic oxide, and potash. Capacity of the pots is approximately 7 cubic feet and the time necessary to fill them varies from 5 to 10 hours.

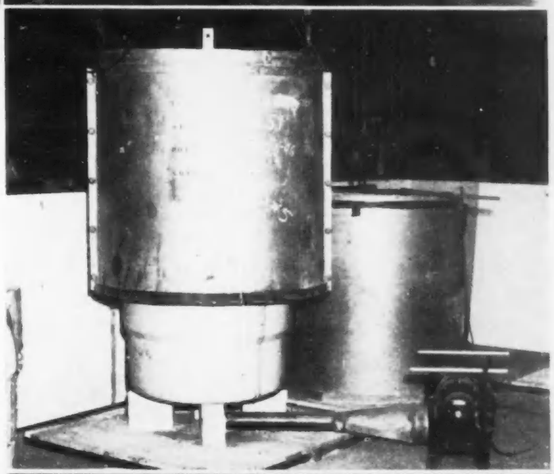
Melting of the batch is accompanied by foaming, and after this has subsided, stirring of the molten glass to obtain uniformity can be started. Stirring is accomplished by means of the thimble which is held in place and actuated by a mechanically driven, water-cooled metal rod. As soon as the molten glass is reasonably free of "seeds," it is gradually cooled in the melting furnace, with decreased rate of stirring, until the viscosity increases to such an extent that further stirring would ruin the glass. The temperature at which this occurs is critical and may vary from 950° to 1,100° C, depending on the type of glass. When the pot of finished glass is removed from the furnace, it is covered with a thermally insulated jacket or can, so that the glass will cool slowly enough to break into fairly large chunks. Breaking open the pot completes the first stage of production.

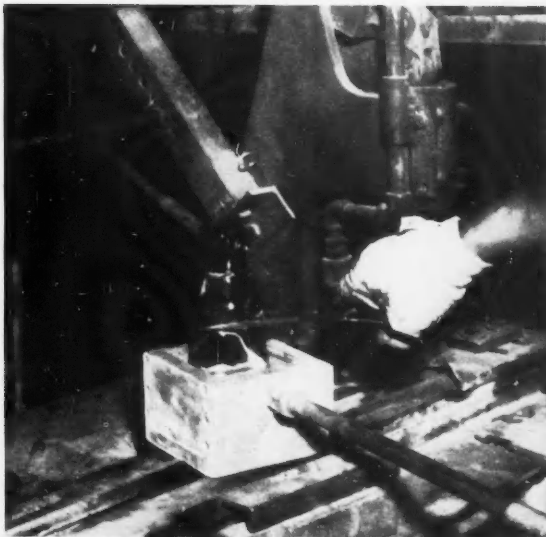
Other major steps that follow as part of the processing of the glass include trimming, molding, annealing, and several inspections. Visible imperfections are trimmed from the rough chunk by means of steel hammers or diamond saws, and the chunks are broken or sawed to a convenient size for molding into blanks. The molding procedure varies according to the size of the blanks, but for all except the largest, molding is by hand.

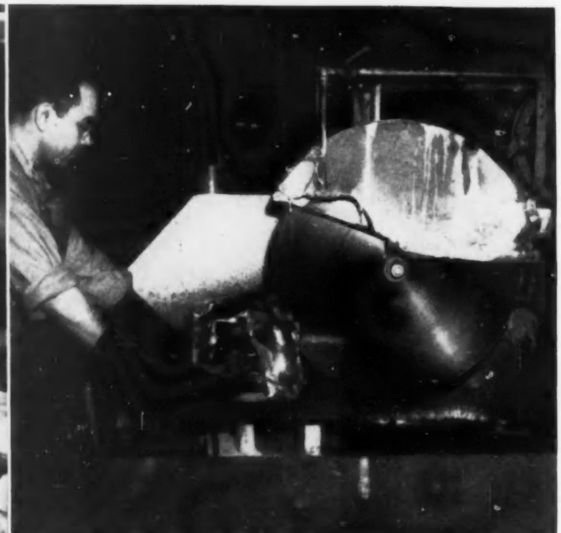
The rough pieces are heated gradually in a preheating furnace to a temperature just below the softening point of the glass and are then picked up by the molder on the end of a steel rod known as the "pontil" rod. Heated well above their softening point in a molding furnace, they are worked into the proper molding shape. The shaped and correctly heated piece of glass is cut off with shears, dropped into a steel mold, and pressed into shape. Another molding procedure is known as paddling. The rough pieces, instead of being picked up on the "pontil" rod, are placed in a paddling furnace, worked into approximate shape with metal paddles, transferred from the furnace, and molded. Removed from the mold, the blanks must be cooled slowly to prevent cracking. Blanks too large to be worked by hand are placed in a ceramic mold and heated gradually until they soften and flow into the shape of the mold.



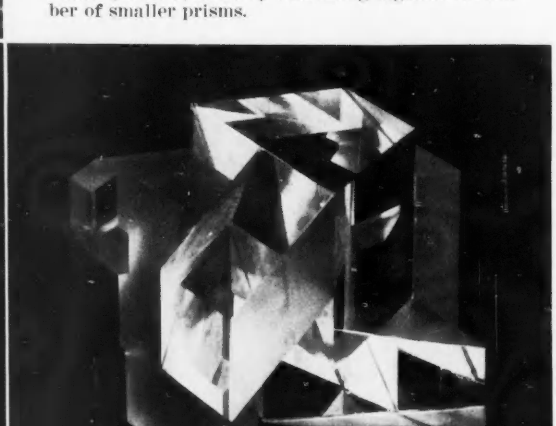
After a preliminary heating, the pot and stirring thimble are placed in the melting furnace (above) and brought up to the melting temperature of the glass it is to hold. The carefully prepared and mixed charge of batch is then gradually introduced (upper right). Capacity of the pots is about 7 cubic feet, and it takes from 5 to 10 hours to fill them. To obtain homogeneity of the glass and freedom from bubbles, the melted glass is stirred by the thimble, which is held in place and actuated by a mechanically driven, water-cooled rod (lower left). Once reasonably free of bubbles, the glass is cooled in the melting furnace, with decreased rate of stirring, until its viscosity increases to the extent that further stirring would ruin the glass. Because the temperature at which this occurs is critical, careful temperature measurements are made with an optical pyrometer (below). When the pot of finished glass is removed from the furnace, it is covered with a thermally insulated jacket (right), so that the glass will cool slowly enough to break into fairly large pieces. After cooling to room temperature, the pots are broken (lower right), and the pieces are tested for imperfections.







Large pieces of glass are sawed with a diamond saw (above) into sizes convenient for molding into blanks. The rough pieces are heated well above their softening point and are then worked into the proper molding shape. The shaped glass is cut off with shears (upper left), dropped into a steel mold, and pressed into shape. Removed from the molds, the blanks are cooled slowly to prevent cracking. Annealing follows, necessary because as the glass passes from the liquid to the solid state, strains are set up that affect the physical as well as optical properties of the glass. The glass blanks are packed into metal cases (left, front) for annealing in electric furnaces (left, rear). Before grinding and polishing, the annealed blanks (lower left), slightly larger than the finished piece, are examined with polarized light for interference figures. Grinding and polishing are the final and painstaking steps in the process from raw ingredients to finished optical specimens, such as the coincidence prism for range finder (below), made by cementing together a number of smaller prisms.



When cooled, the molded blanks are inspected. Immersed in a liquid having an index of refraction similar to that of the glass, the glass surfaces disappear and imperfections in the interior become evident under illumination.

As glass passes from the liquid to the vitreous solid state, strains are set up within the body of the glass. These strains, which seriously affect the physical as well as the optical properties of the glass, are removed by annealing. In the process of annealing, the glass is heated to a temperature just short of its softening point, held at this temperature long enough to remove the strains, and then cooled gradually.

The annealing of optical glass is one of the most important, and at the same time one of the most critical, processes in its production. When properly annealed, an optical element should show no birefringence, should be of uniform index throughout, and the final polished surfaces should not distort with time. Annealing schedules vary widely for the different types of glass, and also for blanks of different weights of the same glass. Each schedule is determined accurately by experimental means.

The temperature is gradually raised to the predetermined annealing temperature and held there until the glass is free of strain. Cooling then follows at such a rate that neither strains nor inequalities in the index develop. The cooling rate is very slow at first, but is gradually increased as the temperature drops.

Before grinding and polishing, a final inspection for strains is made. Again immersed in a liquid of correct index of refraction, the blanks are examined with polarized light for interference figures. About one month elapses between mixing of the batch and the completion of a finished blank, ready for grinding and polishing into an optical element.

Optical Glass in the United States

In normal times comparatively small amounts of optical glass have been produced domestically, in fact some optical-instrument makers have found it economically advantageous to import their glass. Wartime requirements not only multiply the demand enormously, but necessitate exclusively domestic production.

Prior to 1912 no optical glass was being made in this country; in that year, however, one of the large instrument makers began manufacturing their own glass. Two years later, experimental production was started at the Pittsburgh Laboratory of the National Bureau of Standards. A short time later the supply from abroad was cut off, and the Bureau's experimental plant supplied a substantial proportion of military requirements from 1917 through 1918.

From 1919 to 1939, the optical glass laboratory was maintained for research and small scale production, as part of the Bureau's section dealing generally with problems of glass technology. Probably the best-known development during these years was a 70-inch disk successfully completed in 1928 for the telescope of the Perkins Observatory, Ohio Wesleyan University. At the time, the disk represented the largest optical element made in this country.

World War II again brought heavy demands for optical glass, and the Bureau's experimental plant was put into full-scale operation. From this nucleus and with greatly expanded facilities and increased personnel, it became one of the small group of plants supplying this country's optical glass needs. In addition, technical assistance was given several manufacturers who were just entering the field. With this assistance they were able to begin production in a remarkably short time, although they had had no previous experience in optical glass manufacture. Early in the war arrangements were completed for representatives from Canada and Australia to visit the Bureau's laboratory and study methods and equipment. As a result, plants were established and producing optical glass in both countries by 1941.

The most critical time in optical glass production was the earlier part of the war. By the summer of 1944, there was a cut-back in production requirements, and the full output of the commercial optical glass plants as well as the National Bureau of Standards was no longer required. Since the end of the war in Japan the Bureau has been engaged in producing special types of glass and in research and development.

Optical Glass Research

At the beginning of the war six types of optical glass were being made at the Bureau; during the war this was increased to 28 types. Some of these had been made previously, and published information was available on compositions, annealing temperatures, and other physical properties. In these cases little development work was necessary before satisfactory glasses could be made. In other cases entirely new types, on which little or no data previously existed, were developed in the laboratory and then put into full-scale production.

When a new type of glass is required, it is first formulated on the basis of known effects of the various constituents on optical properties such as index of refraction and dispersion. A trial melt of about 50 grams of glass is made in a platinum crucible, and measurements are taken of index of refraction, dispersion, liquidus temperature, softening point, stability of the glass, and other properties. Full-scale melts may then be undertaken.

The behavior of a 50-gram melt heated in a small platinum crucible for a few hours is quite different from the behavior of a large melt heated in the 7-cubic-foot pot for approximately 24 hours, and estimates must be made of such factors as volatilization rate and pot solution. Therefore, the first full-scale melt is seldom satisfactory, and often several trials are necessary before appreciable quantities of suitable glass are obtained. The full-scale pilot plant serves to work out the transition from laboratory to production.

One of the technical innovations developed by the Bureau is the rapid immersion method for measuring the index of refraction and dispersion of glass that eliminates the necessity of grinding and polishing samples for inspection. The method greatly simplified control and was of assistance in development of new glasses. The glass sample is simply matched to an immersion

liquid, using special illumination, and the index of the liquid measured on a precision refractometer. The limiting factor in the accuracy of the index measurements with this apparatus is the precision of the refractometer.

Investigations are now under way to determine the durability of glasses and the mode of attack of various agents producing disintegration of glass. Development of special optical glasses with high index of refraction and low dispersion is also receiving attention. The increasing industrial use of infrared has focused attention on the development of glasses that will extend the range of transmission in this portion of the spectrum, and numerous experimental melts have been made of glasses for this purpose.

Bureau's Graduate School Offers Courses in Science

Fifty-five graduate courses in the fields of mathematics, physics, chemistry, mechanics, and metallurgy are being offered during the 1946–47 academic year by the Graduate School of the National Bureau of Standards. Two types of courses are included: an in-hours series designed specifically for Bureau staff members, and an out-of-hours series in the evenings for properly qualified members of the public as well as the Bureau staff. The faculty consists of nationally known Bureau scientists, many of whom have taught in the Nation's leading universities.

The quarter system has been adopted, and each course consists of 20 lectures, with classes meeting twice weekly. Records will be kept of participation and performance in the courses, and a formal statement of completed work will be issued to students. In the past, graduate credit has usually been given by universities for work done under this program. Partly on the basis of credits obtained through the Bureau courses, over 60 graduate degrees have been awarded by 19 different universities in prior years.

The following courses are offered during the academic year 1946–47:

FIRST QUARTER

Elements of Statistical Inference.
The Differential Equations of Mathematical Physics.
Introduction to Vector Analysis.
Numerical Mathematical Analysis.*
The Physical Nature of the Standard Differential Equations.
Advanced Optics.
Principles of Optical Crystallography.
Piezoelectricity.
Vibration and Sound.
X-Ray Measurements.
Principles of Circuit Analysis.
Electron Emission from Metals.
Electron Tube Fabrication Technique.
Radio Wave Propagation.
Thermodynamics Colloquium.
Chemical Thermodynamics: Fundamental Principles.
Solution Theory and Conductometric Measurements.
High Polymers Colloquium.
Theory of Lubrication.
Determination of Crystal Structure by X-Rays.

SECOND QUARTER

Elements of Statistical Inference.
The Differential Equations of Mathematical Physics.
Numerical Mathematical Analysis.*
Fourier Transforms.
Advanced Optics.
Determination of Optical Properties of Isotropic Materials and Uniaxial Crystals.
Acoustic Measurements.
Vibration and Sound.
X-Ray Measurements.
Emission from Composite Surfaces.
High-Vacuum Techniques.
Introduction to Microwave Theory.
Chemical Thermodynamics: Pure Substances and Solutions.
Measurement of pH by Hydrogen-Electrode and Indicator Methods.
Electronic Interpretation of Organic Chemistry.
Polarographic Analysis.
Fundamentals of Gaseous Combustion.
Strength of Material and Structures.
Corrosion of Metals.

THIRD QUARTER

Correlation and Regression.
Modern Operational Methods in Engineering.
Numerical Mathematical Analysis.*
The Laplace Transformation.
Advanced Optics.
Determination of Optical Properties of Biaxial Crystals.
Ultrasonics.
Vibration and Sound.
X-Ray Measurements.
Secondary Emission.
Electron and Ion Ballistics.
Introduction to Microwave Measurements.
Chemical Thermodynamics: Statistical Calculations; Thermochemical Measurements; Data.
Glass Electrode Methods in pH Measurement of Acidity in Non-Aqueous Solvents.
Selected Topics in Fluid Mechanics.
Heat Treatment of Steel.

Thirty-Second National Conference on Weights and Measures

The Thirty-Second National Conference on Weights and Measures, the first meeting of this Conference since 1941, was held in Washington, D. C., on September 26 to 28, under the sponsorship of the National Bureau of Standards. Registration totaled 242, including official representation from 29 States and the District of Columbia. Letters of greeting were received by the Conference from President Truman and from the Secretary of Commerce.

Among those who addressed the Conference were Dr. E. U. Condon, Director of the Bureau, who welcomed the delegates and outlined the Bureau's position in the field of weights and measures, and Dr. Lyman J. Briggs, Director Emeritus, who described briefly some of the larger war projects in which the Bureau had a part. Dr. Condon was elected President of the Conference, and R. W. Smith, Assistant Executive Officer of the Bureau, Secretary.

*Offered at the Office of the Mathematical Tables Project, New York, New York.

Technical papers, as such, were not presented but emphasis was placed on reports of committees and representatives of weights and measures jurisdictions together with reports and proposals from trade associations, organizations in related fields, and Government agencies. The latter group included the Association of Food and Drug Officials of the United States, represented by Joe C. Schneider; National Scale Men's Association, H. M. Roeser; American Petroleum Institute, J. E. Moss; Gasoline Pump Manufacturers Association, G. D. Moore; Tissue Association, D. A. Crocker; National Association of Scale Manufacturers, Inc., Arthur Sanders; Glass Container Manufacturers Institute, Inc., J. W. Saybolt; the Joint ASME–API Committee on Oil Meter Research, H. S. Bean; United States' Department of Agriculture, L. C. Carey; and the Federal Food and Drug Administration, W. A. Queen.

Open forums featured informal discussions on topics of timely interest, including weighbridges for vehicle scales; State and local requirements for price signs on gasoline-dispensing units; and coordination of Federal, State, and local services.

The Committee on Methods of Sale of Commodities called attention to the fact that during the war mandatory orders of the War Production Board and the Office of Price Administration were effective in the field in which their committee normally functions. The Committee, selecting the best of these and modifying or amplifying others to fit them into the weights and measures structure, incorporated a number of them in their report. Along with certain items not previously given specific treatment through these channels, the Committee's recommendations covered methods of sale of approximately 25 different commodities. The report also included recommendations for quantity declarations on packages of over a hundred individual items. Packaging of frozen foods, sale of ice cream by avoirdupois net weight, and a minimum net weight per dozen for grading of eggs are among the Committee's recommendations adopted by the Conference.

Changes in the codes of specifications and tolerances were accepted to make them more effective and to correct some inequalities in tolerances. Recognizing the need for weights and measures education—for the official, for the legislator, and for the consumer—the Conference voted to continue its Committee on Weights and Measures Education. Emphasizing that the Conference has repeatedly stressed sale by weight instead of by dry measure, a resolution was passed recommending "that every reasonable effort be made to eliminate dry measures in so far as practicable and to establish trading by weight." Several amendments to the Model State Law on Weights and Measures, presented by the Conference Secretary, were also adopted. It was announced that the Weights and Measures News Letter, which has been issued by the National Bureau of Standards for several years, would be discontinued, and that the final issue would be devoted to a summary report of the proceedings of the Conference.

Several committees, which have been largely inactive since 1941 because of conditions beyond their control, have been continued and plan to resume their activities. As conditions return to normal, weights and measures officials, who have assisted in various ways in the war effort—by weighing, metering, and similar means—will be able to devote more time to problems in their specialized field.

Drs. Rossini and Vinal Elected to International Union of Chemistry Posts

Dr. Frederick D. Rossini, chief of the Thermochemistry and Hydrocarbons Section, and Dr. George W. Vinal, chief of the Electrochemistry Section, have been elected presidents of the Committee of Thermochemistry and the Weston Cell Committee, respectively, of the International Union of Chemistry.

The Standing Committee of Thermochemistry, consisting of leading chemists from Poland, France, Belgium, Holland, and the United States, is concerned with achieving international agreements for standards used in thermochemical investigations. The Weston Cell Committee, similarly made up of scientists from the principal nations of the world, is engaged in the scientific development and perfection of the Weston Cell as an international standard of measurement of electromotive force. This committee met in July 1946, for the first time since the beginning of the war.

Dr. Rossini is an authority in thermochemistry and the physical chemistry of hydrocarbons. He has contributed extensively to scientific journals in the fields of thermochemistry, chemical thermodynamics, hydrocarbons, purification of hydrocarbons, and preparation of standard samples of hydrocarbons.

Best known of Dr. Rossini's scientific publications is his book *Thermochemistry of Chemical Substances*, co-authored with Dr. F. Russell Bichowsky. Not only has this publication received world-wide distribution (including translation into Russian), but the Bureau of Standards has undertaken, as an official project, an expanded revision of Dr. Rossini's book for standard use throughout the field of thermochemistry. In recognition of his outstanding work, the Chemical Society of Washington awarded Dr. Rossini the Hillebrand Award for 1934. Dr. Rossini is Supervisor of the American Petroleum Institute Research Projects on the "Analysis, Purification, and Properties of Hydrocarbons" and the "Collection, Analysis, and Calculation of Data on the Properties of Hydrocarbons," being conducted at the National Bureau of Standards.

Dr. Vinal is known for his research in the field of electrochemistry, particularly for his work in the development and perfection of the silver voltameter and the standard cell, which serve as standards for the international ampere and volt. Dr. Vinal has also done extensive research on dry cells and storage batteries.

Best known for his classical book *Storage Batteries*, Dr. Vinal has contributed extensively to scientific journals in the fields of electrochemistry and batteries. In recognition of his outstanding work, France awarded him the Gaston Plante Medal of the Société de Française des Electriciens in 1937.

Laboratories Established for Guided Missiles Research

The organization of two sections within the Bureau dealing with guided missiles research has recently been announced by the Director; the Guided Missiles Section in the Division of Mechanics and Sound, and the Guided Missile Electronics Section in the Ordnance Development Division. Dr. H. K. Skramstad has been designated chief of the former section, and Dr. B. J. Miller, chief of the latter.

The former, previously known as the Special Projects Section, is concerned primarily with extended research and development of the advanced forms of guided missiles, while the latter is responsible for the electronic and servo-mechanisms of these devices. Scientists of these laboratories are currently engaged in research phases of the "Kingfisher Project", advance development of the BAT, the first fully automatic guided missile to be successfully used in combat by any nation. The BAT, a radar-guided bomb, which destroyed many tons of Japanese combatant and merchant shipping during the latter part of the war, was developed by the Guided Missiles Section in close cooperation with the Office of Scientific Research and Development, the Massachusetts Institute of Technology, and the Navy Department.

Dr. Skramstad received a Bachelor of Science degree from the College of Puget Sound, Tacoma, in 1930 and his doctorate from the University of Washington (Seattle) in 1935. Dr. Skramstad came to the National Bureau of Standards in August 1935, as a physicist in the Aerodynamics Section. Until the outbreak of the war, he was engaged in studies of wind tunnel turbulence and the investigation of the stability of laminar flow, important in the mechanics of air flow over surfaces. In 1942, he became Technical Assistant to Dr. H. L. Dryden, Associate Director of the Bureau and Chief of the Mechanics and Sound Division, in the development of guided missiles, playing a key part in the development of the BAT.

Dr. Miller received the Bachelor of Science degree from St. Ambrose College and the Master's and Doctorate of Physics from the University of Iowa. He taught physics at St. Ambrose College and applied mathematics at St. Louis University prior to joining the Bureau staff in 1943. As physicist in the Ordnance Development Division, Dr. Miller played an active part in research phases of the radio proximity fuse, one of the most important wartime accomplishments of the Bureau. Since November 1945, he has been engaged in work on electronics for guided missiles.

New and Revised Publications Issued During October 1946

Journal of Research [1]

Journal of Research of the National Bureau of Standards, volume 37, number 3, September 1946 (RP1736 to RP1741, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

Journal of Research of the National Bureau of Standards, volume 37, number 4, October 1946 (RP1742 to RP1746, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

Research Papers [1]

RP1723. Radio proximity fuze design. Price 10 cents.

RP1724. Assembly, testing, and operation of laboratory distilling columns of high efficiency. Price 10 cents.

RP1725. Nickel plating on steel by chemical reduction. Price 5 cents.

RP1726. Temperature coefficients for proving rings. Price 10 cents.

RP1727. Mutarotation and ring structure of mannuronic lactone. Price 5 cents.

RP1728. Heats of formation and combustion of the normal alkylcyclopentanes and cyclohexanes and the increment per CH_2 group for several homologous series of hydrocarbons. Price 5 cents.

RP1729. Preliminary description and analysis of the first spectrum of uranium. Price 10 cents.

Circular [1]

C455. Flameproofing of textiles. Marjorie W. Sandholzer. Price 10 cents.

Technical News Bulletin [1]

Technical News Bulletin 354, October 1946. Price 5 cents. Annual subscription, 12 issues, 50 cents.

Basic Radio Propagation Predictions [1]

CRPL–D26. Basic radio propagation predictions for January 1947 three months in advance. Issued October 1946. Price 15 cents. Annual subscription, 12 issues, $1.50.

Recent Articles by Members of the Bureau's Staff Published in Outside Journals [2]

Some factors affecting the precision in polarographic analysis. Floyd Buckley and John K. Taylor. Trans. Electrochemical Society (The Secretary of the Society, Columbia University, New York 27, N. Y.) **87**, 463 (1945).

Precision of telescope pointing for outdoor targets. Francis E. Washer and Helen Brubaker Williams. J. Optical Soc. Am. (57 East 55th St., New York 22, N. Y.) **36**, 400 (July 1946).

Looking ahead on building codes. George N. Thompson. Progressive Architecture—Pencil Points (330 West 42nd Street, New York 18, N. Y.) **27**, No. 7, 77 (July 1946).

Some problems and trends in building codes. George N. Thompson. ASTM Bulletin 146, page 33 (August 1946). American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Effect of dimensions of specimens upon the precision of strength data. John Tucker, Jr. Proc. ASTM **45**, 952 (1945).

The maximum stresses present at failure of brittle materials. John Tucker, Jr. Proc. ASTM **45**, 961 (1945).

Effect of length on the strength of compression test specimens. John Tucker, Jr. Proc. ASTM **45**, 976 (1945).

The Cryogenic Laboratory at the National Bureau of Standards. F. G. Brickwedde. Engineering Experiment Station News (Ohio State University, Columbus, Ohio) **18**, No. 3, 30 (June 1946).

Determination of Vinsol resin in portland cement. Leonard Bean and R. B. Peppler. Rock Products (309 W. Jackson Blvd., Chicago 6, Ill.) **49**, No. 7, 71 (July 1946).

[1] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Subscription to Technical News Bulletin, 50 cents a year; Journal of Research, $3.50 a year (to addresses in the United States and its possessions and to countries extending the franking privilege); other countries, 70 cents and $4.50, respectively.

[2] These publications are not available from the Government. Requests should be sent direct to the publishers.

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